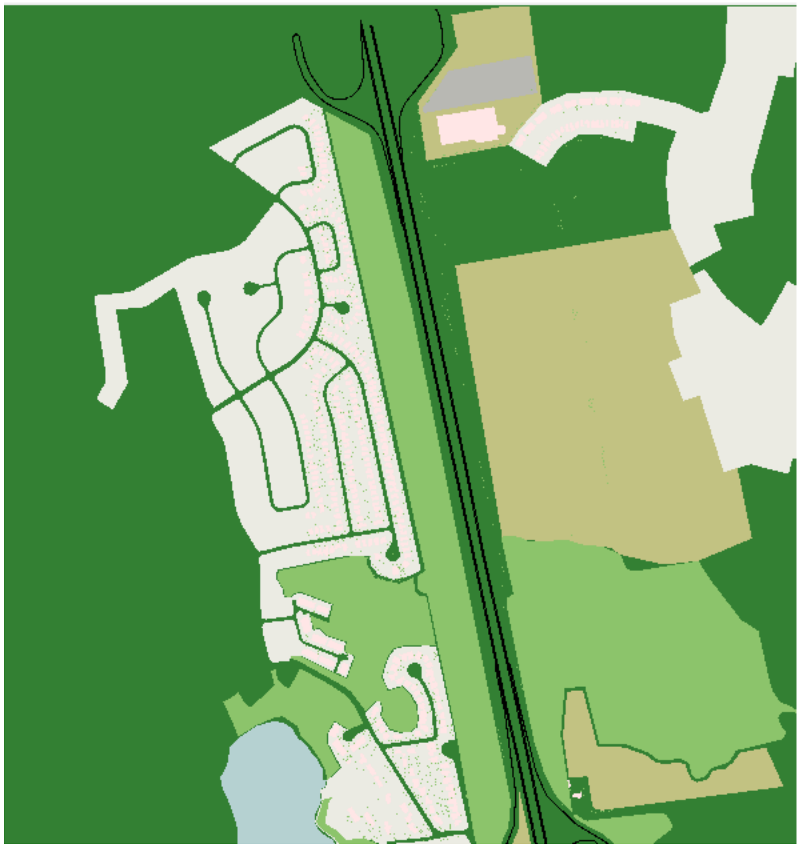
Weekly Updates (14/12/2023) – Krishna Tarun Saikonda

Highway Road Network Details:



The SUMO (Simulation of Urban MObility) map conversion web interface is utilized for generating a simulation of a highway road network in the London area, particularly focusing on Highbury Avenue. This tool accurately captures key aspects of real-world road networks in a specific geographical location, encompassing features like traffic signals, walkways for pedestrians, and various road lanes, thereby replicating the true layout of the map.

Conversion of SUMO .Net File to Lanelet2 Format:

The progression of self-driving car technologies demands the employment of various simulation tools for the modeling and assessment of traffic networks. This document presents the process of transforming a traffic network created by SUMO into formats that are compatible with autonomous driving simulation applications. SUMO's XML format is comprehensive for traffic simulations but necessitates transformation into OpenDRIVE for detailed representations of road networks, and into Lanelet2 for intricate lane-specific details. The CommonRoad Designer acts as the ultimate interface for scenario visualization and modification.

- SUMO: A versatile, open-source road traffic simulation package capable of managing extensive road networks, offering microscopic and continuous simulation.
- OpenDRIVE: A standard file format that intricately details road networks, including lanes, traffic signs, and lights.
- Lanelet2: A sophisticated map format emphasizing the drivable portions of road networks and the applicable rules, offering a segmented road network view.
- CommonRoad Designer: A platform for designing, modifying, and visualizing autonomous driving scenarios, supporting various map formats like Open Street Map (OSM).

Methodology:

Transforming traffic network data from SUMO into Lanelet2, through OpenDRIVE and CommonRoad, is a detailed multi-step procedure that guarantees the preservation of essential road network features as the data shifts across various formats. Each format has a distinct role in the simulation and analysis of traffic networks, making it crucial to convert the data meticulously to preserve its integrity and functionality. From SUMO to OpenDRIVE:

- Conversion Method: Employ the netconvert feature in SUMO to transform XML-based road network descriptions to the OpenDRIVE format.
- Ensuring Data Accuracy: Confirm that the SUMO network is adequately prepped for conversion, tweaking parameters where necessary to ensure the fidelity of the OpenDRIVE result. From OpenDRIVE to CommonRoad:
- Importation Technique: Utilize the capabilities of CommonRoad to import the OpenDRIVE file and adapt it into a CommonRoad scenario, maintaining the structure of the road network and adherence to traffic laws.
- Developing Scenarios: Use the scenario design tools in CommonRoad to enhance the process of visualizing and modifying scenarios for autonomous vehicle simulations. From CommonRoad to Lanelet2:
- Script for Conversion: Implement a specialized script or tool to convert data from CommonRoad scenarios into Lanelet2 format, which includes mapping out road and lane configurations as well as traffic rules.
- Preparing the Final Format: Verify that the Lanelet2 format is comprehensive and exact, making it suitable for sophisticated autonomous driving technologies.

Lanelet2 Format:

The OpenStreetMap (OSM) format used in Lanelet2 will have a specific structure reflecting detailed road network information. In the .osm file, Lanelet2 utilizes a specialized representation that includes various elements to describe road features:

Nodes:

Nodes represent individual points on the map, typically defining coordinates (latitude and longitude) of specific locations or junctions on the road.

```
<node id=1 lat='43.50934231789' lon='-80.53670525588' />
```

Ways:

Ways are ordered lists of nodes representing linear features such as roads, lanes, or other linear elements. They define the shape and geometry of roads and lanes.

```
<way id='10'>
    <nd ref='2' />
    <nd ref='3' />
    <nd ref='4' />
</way>
```

Relations:

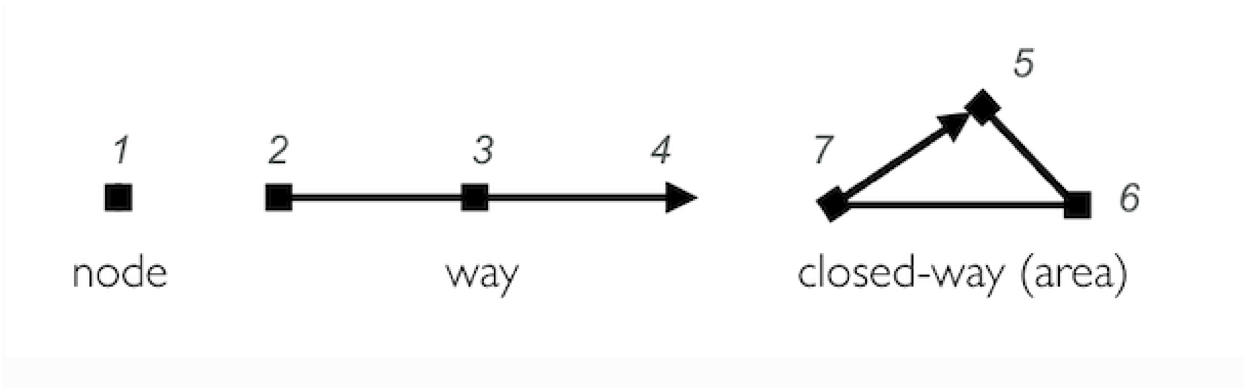
Relations organize different elements together, allowing for the representation of complex structures like intersections, traffic lights, or other related features. They establish connections between various nodes and ways, defining their functional relationships.

Tags:

Tags are key-value pairs assigned to nodes, ways, and relations to provide additional descriptive information about the features. These tags include information such as road types, lane markings, traffic rules, speed limits, or other attributes that define the road network's characteristics.

```
<node id='-1' lat='43.5094' lon='-80.5367'>
   <tag k='gs' v='vehicle'/>
   <tag k='name' v='leading_vehicle'/>
</node>
```

Example:



Generation of FCD output:

I utilized the network (.Net) file and configuration file from SUMO (Simulation of Urban MObility) to extract detailed vehicle data. This data was obtained in the form of an FCD (Floating Car Data) output file.

I employed a specific command, **`--fcd-output.geo`**. This command is a feature in SUMO that enables the conversion of vehicle position data from the simulation's internal coordinate system to a more universally understandable format, namely latitude and longitude coordinates. This conversion is vital for integrating the simulation data with other geographic information systems (GIS) or mapping services, as latitude and longitude are the standard coordinates used globally.

By using this command, each vehicle's position in the SUMO simulation is translated into geographical coordinates. This includes the vehicle's exact location on the earth's surface, which can be overlaid on real-world maps for a more accurate and visual representation of traffic flow and vehicle dynamics. This geospatial data is particularly useful for various applications such as analyzing traffic patterns in specific areas, planning urban mobility strategies, and even in the development and testing of autonomous vehicle systems, where understanding the real-world context of vehicle movement is essential.

```
<timestep time="25.00">
    <vehicle id="veh1" x="-81.190014" y="42.962643" angle="167.84" type="veh_passenger" speed="24.85" pos="5.10" lane="319032606_0" s
</timestep>
<timestep time="25.50">
    <vehicle id="veh1" x="-81.189982" y="42.962534" angle="167.84" type="veh_passenger" speed="24.67" pos="17.43" lane="319032606_0"
</timestep>
<timestep time="26.00">
    <vehicle id="veh1" x="-81.189950" y="42.962426" angle="167.84" type="veh_passenger" speed="24.66" pos="29.77" lane="319032606_0"
</timestep>
<timestep time="26.50">
    <vehicle id="veh1" x="-81.189918" y="42.962318" angle="167.84" type="veh_passenger" speed="24.48" pos="42.00" lane="319032606_0"
```

FCD data in SUMO Representation

Converting FCD (Floating Car Data) into Lanelet2 Representation:

In this process, I am utilizing the latitude and longitude information for each vehicle at every timestamp, extracted from the FCD (Floating Car Data) of a traffic simulation. This geographical data represents the precise locations of vehicles at specific times. My objective is to determine the nearest node (a specific point in the road network) from the Lanelet2 map file to each vehicle's position.

Once I identify the closest node for every vehicle, I assign this node to the respective vehicle, effectively linking each vehicle to a specific point in the road network. This linkage is crucial for understanding how vehicles interact with the physical road infrastructure.

Next, I delve deeper into the road network data. For each node now associated with a vehicle, I identify the "way" it belongs to. In road network terminology, a "way" is essentially a segment or path in the road network, like a particular road or lane. By finding out which way a node belongs to, I can assign this way ID to the vehicle, further refining its location within the road network.

The process doesn't stop there. I also extract the "lanelet" ID from the way. A lanelet is a more detailed element of the road network, providing additional context like the specific lane a vehicle is in. This detailed mapping is crucial for advanced traffic analysis and simulations, as it offers a granular view of vehicle movements and positions.

Finally, with all this new and detailed information – the closest node, the associated way, and the lanelet ID – I update a new FCD XML file. This file now contains enriched data, combining the original vehicle positions with their corresponding detailed locations within the road network. Such comprehensive data is invaluable for traffic studies, urban planning, and simulations, offering a holistic view of how vehicles navigate and interact within a structured road environment.


```
"veh1" x="-81.189739" y="42.961715" type="veh_passenger" speed="23.32" lane="319032606_0" node_id="15306" way_id="15752" lanelet_id="15753

30.00">
"veh1" x="-81.189708" y="42.961612" type="veh_passenger" speed="23.50" lane="319032606_0" node_id="14657" way_id="15082" lanelet_id="15753

30.50">
"veh1" x="-81.189678" y="42.961508" type="veh_passenger" speed="23.55" lane="319032606_0" node_id="15353" way_id="15752" lanelet_id="15753

31.00">
"veh1" x="-81.189647" y="42.961405" type="veh_passenger" speed="23.54" lane="319032606_0" node_id="15376" way_id="15752" lanelet_id="15753
```


Lanelet Representation